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(54) Title: PHARMACEUTICAL FORMULATIONS CONTAINING BETA-LACTAM ANTIBIOTICS AND AN ALKYL SULPHATE SURFACTANT

(57) Abstract

Pharmaceutical formulations, in particular beta-lactam antibiotic formulations in the form of substantially spherical granules, using a metal alkyl sulphate as a spheronizing agent.

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# Pharmaceutical formulations containg beta-lactam antibiotics and an alkyl sulphate surfactant

This invention relates to pharmaceutical formulations, in particular to beta-lactam antibiotic formulations in the form of substantially spherical granules.

In the manufacture of pharmaceutical formulations in which the active ingredient comprises a beta-lactam antibiotic and/or beta-lactamase inhibitor, it is frequently necessary to provide the formulation in the form of granules, for example for making up into tablets, capsules or sachet formulations etc. For certain applications in particular when such granules have to be coated, for example with a water-resistant or enteric coating to delay dissolution after oral ingestion, it is desirable that the granules are substantially spherical.

The term "substantially spherical" as used herein is intended to include spherical, ellipsoidal, e.g. of eccentricity up to no more than 2, preferably up to no more than 1.5, oblate spheroidal, e.g. having its longest axes up to no more than 2 times, preferably up to no more than 1.5 times longer than its shortest axis, polyhedral with at least 12 faces having predominantly curved rather than angular edges, and substantially equiaxial. The term also includes the shape of what are known in the art as "marums". The terms "spheronised" and "spheronisation" are terms of the art.

It is particularly desirable to have substantially spherical granules when granules of relatively water soluble antibiotics, and of beta-lactamase inhibitors such as salts of clavulanic acid such as potassium clavulanate are to be coated, as the angles of angular granules can present weak points in the coat via which the antibiotic or inhibitor may be leached out. Problems have been encountered in providing such antibiotics and beta-lactamase inhibitors in the form of granules, particularly in the form of substantially spherical granules.

According to this invention, there is provided a pharmaceutical granule, comprising:

an active ingredient which comprises one or more beta-lactam antibiotics and/or one or more beta-lactamase inhibitors; and one or more surfactants which are Group I or Group II metal ($C_{10-17}$) alkyl sulphates.

The invention further provides a process for the preparation of a pharmaceutical granule, comprising admixing one or more beta-lactam antibiotics, and/or one or more beta-lactamase inhibitors with one or more surfactants which are Group I or Group II metal ($C_{10-17}$) alkyl sulphates, and then granulating the mixture.

The granule is primarily intended for oral administration, and consequently preferred antibiotics are orally absorbed penicillins (which term

includes penicillins penems, penams, carbapenems etc.) or cephalosporins. Preferred beta-lactam antibiotics are amoxycillin, for example as its trihydrate, and ampicillin. A preferred beta-lactamase inhibitor is a salt of clavulanic acid, especially group I metal salts thereof such as potassium clavulanate. A preferred combination of beta-lactamase inhibitor and antibiotic is potassium clavulanate : amoxycillin, as amoxycillin trihydrate or sodium amoxycillin, for example as crystalline anhydrous sodium amoxycillin as described in EP 0131147. A preferred ratio of clavulanate : amoxycillin is in the range 1 : 1 to 1 : 12 inclusive, particularly 1 : 2 to 1: 8, expressed in terms of weight ratios of the free acids.

Suitably the Group I or Group II metal alkyl sulphate has a formula $[(C_nH_{2n+1})SO_4^-]_mM^{m+}$ where M is a group I or II metal cation of ionic charge m and n is an integer between 10 and 17. The surfactant(s) is preferably a sodium alkyl sulphate, for example sodium lauryl sulphate.

The granule may also comprise conventional granulating aids such as polyvinylpyrrolidone such as Kollidon K12-30 (Trade Mark) or the proprietary hydroxymethyl cellulose material "Pharmacoat 603" (Trade Mark), fillers / spheronising aids such as colloidal silica such as Aerosil 200 (Trade Mark) and/or cellulose derivatives such as microcrystalline cellulose, e.g. Avicel (Trade Mark).

When the granule comprises or contains a salt of clavulanic acid, e.g. potassium clavulanate either as the sole beta-lactamase inhibitor content or in admixture with other beta-lactamase inhibitors then it is preferred that the granule also contains an amino acid, suitably glycine.

The relative proportions of the above components in the granule are suitably as follows. Antibiotic, beta-lactamase inhibitors or combination thereof: 50 wt. % or more e.g. 80% or more. Surfactant: 0.5 - 5 wt. % e.g. 0.5 - 1.5 wt. %. Granulating aid: 0 - 7.5 wt. %, typically if the granule comprises or contains a salt of clavulanic acid as the sole or principal active ingredient content or in admixture with another antibiotic 3 - 7.5 wt. %, e.g. 4 $\pm$ 1 wt. %. Fillers/spheronising aids 0 - 25 wt. % e.g. 0 - 10 wt. %. If an amino acid is present in the granule, for example together with a salt of clavulanic acid, then suitably 1 - 50 wt. %, e.g. 5 - 15 wt. %. may be present. These weight percentages are expressed as total granule weight.

The shape of the granules is preferably substantially spherical, as defined above, with a size range between 10-44 mesh, e.g. 12-30 mesh.

The invention further provides a process for the preparation of a pharmaceutical granule, comprising admixing one or more beta-lactam antibiotics, and/or one or more beta-lactamase inhibitors with one or more surfactants which

are Group I or Group II metal ($C_{10-17}$) alkyl sulphates, and then granulating the mixture.

These granules may be prepared by a granulation process comprising for example mixing the milled ingredients with a suitable liquid, or by mixing the milled ingredients less the granulating aid with a solution or suspension of the granulating aid, followed by extrusion and preferably spheronisation, e.g. "marumerisation". When the antibiotic comprises a relatively water-insoluble antibiotic such as amoxycillin trihydrate the suitable liquid may be an organic liquid or water, and when the antibiotic comprises a relatively water-soluble antibiotic such as clavulanate a suitable liquid may be an organic liquid such as an isopropyl alcohol: methylene dichloride mixture, typically in a 1:2-3 volume: volume ratio.

Salts of clavulanic acid, such as potassium clavulanate are extremely water sensitive, so it is important that such salts are handled in extremely dry conditions, suitably 30% RH or less.

It has been found that spheronised granules, such as marums may conveniently be prepared using the above formulations and process.

The granules of this invention, especially substantially spherical granules, are suited to coating, for example with water-resistant or enteric coatings. This is particularly so in the case of granules of the invention in which the active ingredient comprises or includes a salt of clavulanic acid.

Therefore the invention also provides a granule as described above, coated with a coating, which may be an at least partly water-resistant, suitably an enteric, coating.

The invention also provides a process wherein a granule as described above is coated with a coating, which may be an at least partly water-resistant, suitably an enteric, coating.

An enteric coating may for example be an essentially conventional enteric coating material known for coating antibiotic granules.

Suitable coating materials are pharmaceutically acceptable methacrylic acid copolymers such as those described in the USP/NF, and such polymers of types A, B and C as described therein may be suitable. Suitable generic classes and specific examples of pharmaceutically acceptable methacrylic acid copolymer are known polymers which are copolymers of acrylic and methacrylic esters with a low content of quaternary ammonium groups, for example having a molar ratio of such ammonium groups : remaining (meth)acrylic esters of 1 : $\geq$ 10, for example around 1 : 20 or 1 : 40, and with a mean molecular weight of around 150000. Such polymers correspond to USP/NF 2 "Ammonio methacrylate copolymers, Type A and Type B".

Further suitable generic classes and specific examples of pharmaceutically acceptable methacrylic acid copolymer are known polymers which are copolymers, anionic in character, based on methacrylic acid and methyl methacrylate, for example having a ratio of free carboxyl groups : methyl-esterified carboxyl groups of 1 : >3, e.g. around 1 : 1 or 1 : 2, and with a mean molecular weight of 135000.

Such polymers are sold under the trade name Eudragit ™, such as the Eudragit L series e.g. Eudragit L 12.5 ™, Eudragit L 12.5P ™, Eudragit L100 ™, Eudragit L 100-55 ™, Eudragit L-30 ™, Eudragit L-30 D-55 ™, the Eudragit S ™ series e.g. Eudragit S 12.5, Eudragit S 12.5P ™, Eudragit S100 ™, the Eudragit NE™ series e.g Eudragit NE 30D ™, the Eudragit RL ™ series, e.g. Eudragit RL 12.5 ™, Eudragit RL 100 ™, Eudragit RL PO ™, Eudragit RL 30D ™, and the Eudragit RS ™ series e.g. Eudragit RS 12.5 ™, Eudragit RS 100 ™, Eudragit RS PO™, and Eudragit RS 30D™ . Some of these polymers are known enteric polymers (the term "enteric polymer" is a term of the art referring to a polymer which is preferentially soluble in the less acid environment of the intestine relative to the more acid environment of the stomach), for example having a solubility in aqueous media at pH 5.5 and above. These Eudragit polymers may be used either alone or with a plasticiser.

The coating may be applied using either an aqueous medium or a non-aqueous medium such as an organic liquid, for example a methanol: methylene dichloride mixture. A non-aqueous medium may be more suitable if the active ingredient comprises or contains a clavulanate salt. The choice of plasticiser will depend upon whether an aqueous or non-aqueous medium is used, for example suitable plasticisers for an aqueous medium include propylene glycol, triethyl citrate or acetyl triethyl citrate, and for a non-aqueous medium include these and also dibutyl or diethyl phthalate. The coating may also include an anti-tack agent such as talc or silica. The enteric coating may be applied using an essentially conventional method, for example dissolving or suspending the enteric coating material in the medium, then spraying the solution or suspension onto the granules, followed by drying and screening.

The granules of this invention may be made up into pharmaceutical formulations in a conventional manner, e.g. by packing into sachets or other containers, or by tabletting, e.g. by a conventional process of compaction to provide a tablet formulation. The invention therefore also provides a tablet which includes the above-described granules.

The invention also provides a process for the use of a granule as described above in the manufacture of a medicament for the treatment of bacterial infections.

The invention also provides a method of treatment of bacterial infections in humans and animals which comprises the administration of a therapeutically effective amount of granules as described above.

The invention also provides pharmaceutical granules as described above for use in the treatment of bacterial infections.

The following examples illustrate the invention.

| **Example 1** | **mg/dose** |
|---|---|
| Amoxycillin trihydrate | 300 f.a. |
| Colloidal silica | 1.8 |
| Sodium lauryl sulphate | 3.6 |
| Kollidon 25 (polyvinylpyrrolidone) | 5.4 |
| Eudragit L100 | 14.0 |
| Propylene glycol | 1.4) Solids from |
| Aerosil 200 | 1.0) Enteric coat |

The first four ingredients were granulated using water and then enteric coated using methylene dichloride/methanol (60/40 v/v).

| **Example 2** | **mg/dose** |
|---|---|
| Potassium clavulanate | 150 f.a. |
| Pharmacoat 603 | 9 |
| Colloidal silica | 3.4 |
| Glycine | 22.5 |
| Sodium lauryl sulphate | 2.3 |
| Eudragit L100 | 152.1) |
| Diethyl phthalate | 19.1) Solids from |
| Talc | 22.8) Enteric coat |

The first four ingredients were granulated using methylene dichloride/methanol (70/30 v/v). and then enteric coated using methanol/methylene dichloride (40/60 v/v).

| Example 3 | mg/dose |
|---|---|
| Potassium clavulanate | 1002.0g. |
| Pharmacoat 603 | 48.0g |
| Colloidal silica | 18.0g |
| Glycine | 120.0g |
| Sodium lauryl sulphate | 12.0g |

| Granulating mixture: | |
|---|---|
| Isopropyl alcohol | 300ml |
| Methylene dichloride | 700ml |
| Eudragit L100 | 334g |
| Diethyl phthalate | 42g |
| Talc | 50g |
| Methanol | 2000ml |
| Methylene dichloride | 3000ml |

**Process**

Screen the potassium clavulanate 16 mesh. Screen the Aerosil and Pharmacoat 20 mesh. Blend all ingredients in a planetary mixer for 5 minutes, then granulate with the granulating mixture. (The above weights of solid ingredients require approximately 460ml.of granulating mixture.) Extrude the granules through a 1mm. aperture and marumerise, wetting the particles slightly with granulating mixture as necessary. Dry the marums in a fluid bed dryer for 45 minutes at 45°C. Screen the marums, retaining those between 12 and 30 mesh. Prepare the coating solution by dispersing the Eudragit in the methylene dichloride using a high speed mixer. Add the methanol and stir until the solution clears. Add the diethylphthalate and talc. Stir for 15 minutes. Load the marums into a coating pan and warm for at least 15 minutes. Spray the coating solution on the tumbling marum bed at about 25 ml/min. 15 litres of solution was sprayed on to 2100 g. of marums. Screen the dried, coated marums.

| Example 4 | |
|---|---|
| Amoxycillin trihydrate | 4900g |
| Colloidal silica (Aerosil 200) | 25g |
| Sodium lauryl sulphate | 50g |

**Granulating solution**

| | |
|---|---|
| Polyvinylpyrrolidone (Kollidon 25, Trade Mark) | 75g |
| Water | 1463g |

**Coating solution**

| | |
|---|---|
| Eudragit L100 (Trade Mark) | 200g |
| Colloidal silica | 15g |
| Propylene glycol | 20g |
| Dichloromethane | 1800g |
| Methanol | 1200g |

**Process**

Blend the amoxycillin trihydrate, colloidal silica and sodium lauryl sulphate in a planetary blender. This is wet massed with the granulating solution, and the resulting granules are extruded at medium speed on a (EXKS-1) extruder fitted with a 0.7 mm screen. The extrudate is then spheronised at fast speed on the Marumeriser, allowing a residence time for extrudates of 1-2 minutes. Marums are dried in a fluid bed drier for 2 hours at 60°C in divided lots of 2-3kg. These are subsequently blended and the fraction <14#>30# retained.

**Coating**

The constituents of the coating suspension are mixed until uniform. The vessel of a fluidised bed coater previously fitted with a spray gun for co-current application is loaded with 1kg granules. The bed is warmed for a few minutes with warm inlet air. Spray the coating suspension until sufficient coat is applied.

**Example 5**

| | | |
|---|---|---|
| 1 | Potassium clavulanate | 1002.0g |
| 2 | Pharmacoat 603 | 48.0g |
| 3 | Colloidal silica | 18.0g |
| 4 | Glycine | 120.0g |
| 5 | Sodium lauryl sulphate | 12.0g |

**Granulating solution**

| | | |
|---|---|---|
| 6 | Isopropyl alcohol | 300ml |
| 7 | Methylene dichloride | 700ml |

**Coating suspension**

| | | %w/w |
|---|---|---|
| 8 | Eudragit L300 | 52.2 |
| 9 | Citroflex A2 (acetyltriethylcitrate) (equivalent to 10% dry lacquer) | 1.6 |
| 10 | Talc | 7.8 |
| 11 | Water | 38.4 |

**Process**

Screen the potassium clavulanate through 16 mesh screen.
Screen the colloidal silica and Pharmacoat through 20 mesh screen
Blend all the ingredients in a planetary mixer for 5 minutes, then granulate with the granulating solution. (The weights above require approximately 460ml of solution).
Extrude the granules through a 1mm aperture and marumerise, wetting the particles slightly with granulating solution as necessary.
Dry the marums in a fluid bed drier for 45 minutes at 40°C.
Screen the marums, retaining those between 12 and 30 mesh.

**Coating**

The constituents of the coating suspension are mixed until uniform using a high shear mixer (e.g. Silverson).

The vessel of a fluid bed granulator, having previously been fitted with a spray gun for co-current application, is loaded with an appropriate weight of marums.

The bed of marums is warmed for 5 minutes at an air inlet temperature of 40°C.
The coating suspension is sprayed at a flow rate of approximately 3 to 4 L per minute at an atomising pressure of 0.2 bar. Sufficient coat is applied so that the coated marums meet the following dissolution requirements. The clavulanate is essentially not released at pH 2 and 4 (preferably less than 10% of the clavulanate content being released of this pH), and achieve almost total release (greater than 80%, and preferably greater than 90%) by the end of the test at pH 7.

Note: approximately 400g of coating suspension (= 63g of solids) is needed for each 100g of marums.

The coated marums are dried for 10-15 minutes at 40°C.
The dried, coated marums are screened and those between 10 and 12 mesh are retained.

**Claims:**

1. A pharmaceutical granule, comprising: an active ingredient which comprises one or more beta-lactam antibiotics and/or one or more beta-lactamase inhibitors; and one or more surfactants which are Group I or Group II metal ($C_{10-17}$) alkyl sulphates.

2. A pharmaceutical granule according to claim 1 characterised in that the antibiotic is selected from amoxycillin and ampicillin, and the beta-lactamase inhibitor is a salt of clavulanic acid.

3. A pharmaceutical granule according to claim 2 characterised in that the beta-lactamase inhibitor is potassium clavulanate and the antibiotic is amoxycillin

4. A pharmaceutical granule according to any one of claims 1 to 3 characterised in that the surfactant(s) is a sodium alkyl sulphate.

5. A pharmaceutical granule according to claim 4 characterised in that the surfactant is sodium lauryl sulphate.

6. A pharmaceutical granule according to any one of claims 2 to 5 characterised in that the granule also contains an amino acid.

7. A pharmaceutical granule according to any one of claims 1 to 6 characterised in that the relative proportions of the components in the granule are: antibiotic, beta-lactamase inhibitors or combination thereof: 50 wt. % or more; surfactant: 0.5 - 5 wt. %; granulating aid: 0 - 7.5 wt. %; fillers/spheronising aids 0 - 25 wt. % expressed as total granule weight.

8. A pharmaceutical granule according to any one of claims 1 to 7 coated with a coating which may be an at least partly water-resistant.

9. A process for the manufacture of a pharmaceutical granule, comprising admixing one or more beta-lactam antibiotics, and/or one or more beta-lactamase inhibitors with one or more surfactants which are Group I or Group II metal ($C_{10-17}$) alkyl sulphates, and then granulating the mixture.

10. A process wherein a granule according to any one of claims 1 to 7 is coated with an at least partly water resistant coating.

11. A pharmaceutical tablet which includes granules according to any one of claims 1 to 8.

12. A process characterised in that granules according to any one of claims 1 to 8 are compacted into a pharmaceutical tablet.

13. A process for the use of a granule according to any one of claims 1 to 8 in the manufacture of a medicament for the treatment of bacterial infections.

14. A method of treatment of bacterial infections in humans and animals which comprises the administration of a therapeutically effective amount of granules according to any one of claims 1 to 8.

# INTERNATIONAL SEARCH REPORT

Intern al Application No
PCT/EP 95/01039

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A61K31/43 A61K9/16 A61K47/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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[X] Further documents are listed in the continuation of box C.

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